Tennessee Science Curriculum Framework

Principles of Technology II

Course Description

Principles of Technology II is a laboratory science course that deals with the relationship between matter and energy and how they interact. This course will have a strong emphasis in the application of physics in technology. Completion of Principles of Technology I and II is equivalent to a credit in physics.

Principles of Technology II students will study:

- Momentum
- Waves and Vibrations
- Energy Convertors
- Transducers
- Radiation
- Light and Optical Systems
- Time Constants

Embedded Inquiry

Conceptual Strand

Understandings about scientific inquiry and the ability to conduct inquiry are essential for living in the 21st century.

Guiding Question

What tools, skills, and knowledge are needed to conduct scientific inquiry?

Course Level Expectations

CLE 3256.Inq.1 Recognize that science and technology are progressive endeavors that reevaluate and extend what is already accepted.

CLE 3256.Inq.2 Design and conduct scientific investigations to explore new phenomena, verify previous results, test how well a theory predicts, and compare opposing theories.

CLE 3256.Inq.3 Use appropriate tools and technology to collect precise and accurate data.

CLE 3256.Inq.4 Apply qualitative and quantitative measures to analyze data and draw conclusions that are free of bias.

CLE 3256.Inq.5 Compare experimental evidence and conclusions with those drawn by others about the same testable question.

CLE 3256.Inq.6 Communicate and defend scientific findings.

Checks for Understanding (Formative/Summative Assessment)

- ✓**3256.Inq.1** Conduct scientific investigations that include testable questions, verifiable hypotheses, and appropriate variables to explore new phenomena or verify the experimental results of others.
- ✓**3256.Inq.2** Select appropriate independent, dependent, or controlled variables for an experiment.
- ✓**3256.Inq.3** Analyze the components of a properly designed scientific investigation.
- ✓**3256.Inq.4** Perform an experiment to test a prediction.
- ✓**3256.Inq.5** Select appropriate tools and technology to collect precise and accurate quantitative and qualitative data.
- ✓**3256.Inq.6** Determine if data supports or contradicts a hypothesis or conclusion.
- ✓**3256.Inq.7** Recognize, analyze, and evaluate alternative explanations for the same set of observations.
- ✓**3256.Inq.8** Evaluate the accuracy and precision of data.
- ✓**3256.Inq.9** State a conclusion in terms of the relationship between two or more variables.
- ✓**3256.Inq.10** Defend a conclusion based on scientific evidence.
- ✓**3256.Inq.11** Analyze experimental results and identify possible sources of bias or experimental error.
- ✓**3256.Inq.12** Compare the results of an experiment with what is already known about the topic under investigation.
- ✓**3256.Inq.13** Suggest alternative explanations for the same set of observations.
- ✓**3256.Inq.14** Formulate and revise models using logic and evidence.
- ✓**3256.Inq.15** Compare conclusions that offer different, but acceptable explanations for the same set of experimental data.

Embedded Mathematics

Conceptual Strand

Investigating physics principles is accomplished by applying mathematical rules.

Guiding Question

What skills and understandings of mathematics are needed to investigate physics?

Course Level Expectations

- **CLE.3256 Math.1** Graph relationships and functions between manipulated (independent) variables and responding (dependent) variables.
- **CLE.3256 Math.2** Solve for variables in an algebraic formula.
- **CLE.3256 Math.3** Apply statistical techniques to manipulate data.
- **CLE.3256 Math.4** Investigate trigonometric connections to physics.

Checks for Understanding (Formative/Summative Assessment)

- ✓**3256.Math.1** Plot points on the Cartesian coordinate graphing system.
- ✓**3256.Math.2** Graph basic relations and functions.
- ✓**3256.Math.3** Determine the slope of a linear function.
- ✓**3256.Math.4** Determine the frequency, range, mode, median, and mean from a list of data.
- ✓**3256.Math.5** Utilize a graphing calculator or a computer program to enter data and find basic statistics: frequency, range, means, mode, median, and standard deviation.
- ✓**3256.Math.6** Solve for all variables based on a formula.
- ✓**3256.Math.7** Utilize trigonometric functions (sine, cosine, and tangent) to solve simple vector problems.
- ✓**3256.Math.8** Apply the laws of sine and cosine to solve vector problems.
- ✓**3256.Math.9** Solve mechanics problems using the quadratic formula.
- ✓**3256.Math.10** Solve mechanics problems using radians, degrees and revolutions.

Embedded Technology and Engineering

Conceptual Strand

Society benefits when engineers apply scientific discoveries to design materials and processes that develop into enabling technologies.

Guiding Question

How do science concepts, engineering skills, and applications of technology improve the quality of life?

Course Level Expectations

- **CLE 3256.T/E.1** Explore the impact of technology on social, political, and economic systems.
- **CLE 3256.T/E.2** Differentiate among elements of the engineering design cycle: design constraints, model building, testing, evaluating, modifying, and retesting.
- **CLE 3256.T/E.3** Explain the relationship between the properties of a material and the use of the material in the application of a technology.
- **CLE 3256.T/E.4** Describe the dynamic interplay among science, technology, and engineering within living, earth-space, and physical systems.
- **CLE 3256.T/E.5** Comply with all local, state, and federal safety regulations.

Checks for Understanding (Formative/Summative Assessment)

- ✓**3256.T/E.1** Distinguish among tools and procedures best suited to conduct a specified scientific inquiry.
- ✓**3256.T/E.2** Apply the engineering design process to construct a prototype that meets developmentally appropriate specifications.

✓**3256.T/E.3** Evaluate a protocol to determine the degree to which an engineering design process was successfully applied.
✓**3256.T/E.4** Explore how the unintended consequences of new technologies can impact human and non-human communities.
✓**3256.T/E.5** Evaluate the overall benefit to cost ratio of a new technology.
✓**3256.T/E.6** Present research on current bioengineering technologies that advance health and contribute to improvements in our daily lives.
✓**3256.T/E.7** Design a series of multi-view drawings that can be used by other students to construct an adaptive design and test its effectiveness.
✓**3256.T/E.8** Apply industry standard measurements and identifiers.

Standard 1 – Momentum

Conceptual Strand 1

Laws of momentum are the foundations of the motions of objects.

Guiding Question 1

How do the laws and properties of momentum govern the basic understanding of motion?

Course Level Expectations

CLE 3256.1.1 Describe linear momentum and its relationship to mass and velocity.
CLE 3256.1.2 Describe angular momentum and its relationship to moment of inertia and angular velocity.
CLE 3256.1.3 Describe impulse.
CLE 3256.1.4 State the law of conservation of momentum as it affects linear or angular motion.
CLE 3256.1.5 Describe the relationship of impulse to change in momentum.

Checks for Understanding (Formative/Summative Assessment)

✓**3256.1.1a** Define linear momentum.
b Identify appropriate English and SI units for linear momentum.
. c Calculate the linear momentum of an object.
d Apply momentum equations to the movement of objects and fluids.
✓**3256.1.2a** Define angular momentum.
b Identify appropriate English and SI units for angular momentum.
c Calculate angular momentum of an object.
d Apply momentum equations to the rotation of objects.
✓**3256.1.3a** Define linear impulse.
b Define angular impulse.
✓**3256.1.4a** Describe the conservation of linear momentum in isolated systems.
b Identify workplace applications where technicians measure or control linear and angular momentum.
✓**3256.1.5a** Explain how the linear impulse ($F\Delta t$) is related to a change in the linear momentum $\Delta(mv)$.

b Solve a problem that involves conservation of linear momentum.
c Explain how angular impulse relates to a change in angular momentum.
d Solve a problems that involves conservation of angular momentum.

Standard 2 – Waves and Vibrations

Conceptual Strand 2

The principles and laws of wave motion are essential for understanding the concept of wave energy.

Guiding Question 2

How do the laws of wave motion relate to understanding the use of waves as a form of energy?

Course Level Expectations

CLE 3256.2.1 Describe wave motion in general.
CLE 3256.2.2 Describe how waves transmit (move) energy.
CLE 3256.2.3 List the characteristics that are used to describe a wave.
CLE 3256.2.4 Distinguish between longitudinal and transverse waves.
CLE 3256.2.5 Measure wave characteristics.

Checks for Understanding (Formative/Summative Assessment)

✓**3256.2.1a** Describe a harmonic wave (sine wave).
b Identify examples of wave interference.
c Define natural frequency of an object.
d Define resonance.

✓**3256.2.2a** Define wave speed for a traveling harmonic wave.
b State what is meant by the phase difference between two harmonic waves.
c Describe what is meant by interference of waves.
d Describe what is meant by superposition of waves..
e Distinguish between constructive and destructive interference.
f Research for examples of wave resonance.
g Identify workplace applications where technicians measure and control waves and vibrations.

✓**3256.2.3a** Define and experiment with wavelength of a harmonic wave.
b Define and experiment with frequency of a harmonic wave.
c Define and experiment with period of a harmonic wave.
d Define and experiment with amplitude of a harmonic wave.
e Define the phase of a harmonic wave.
f Solve problems that involve wave characteristics.
e Describe what is meant by a standing wave.

✓**3256.2.4a** Distinguish between the characteristics of a wave.
b Define the frequency of a harmonic wave.
c Classify waves as longitudinal or transverse.
✓**3256.2.5a** Measure the characteristics of a wave.
b Calculate natural frequency and period of oscillation of several vibrating systems.
c Use a transducer to measure the vibrations of a vibrating structure.
d Use a dual trace oscilloscope to compare the output from two vibration transducers.

Standard 3 – Energy Converters

Conceptual Strand 3

Understanding how energy is converted from one form to another is essential to design and operation of machines in technology.

Guiding Question 3

How do energy converting devices function?

Course Level Expectations

CLE 3256.3.1 Describe the purpose of an energy convertor.
CLE 3256.3.2 Identify mechanical energy convertors.
CLE 3256.3.3 Identify and investigate fluid energy convertors.
CLE 3256.3.4 Identify and investigate electrical energy convertors.
CLE 3256.3.5 Identify and investigate thermal energy convertors.
CLE 3256.3.6 Describe energy convertors and calculate their efficiency.

Checks for Understanding (Formative/Summative Assessment)

✓**3256.3.1a** Experiment with a mechanical energy convertor.
b Experiment with a fluid energy convertor.
c Experiment with an electrical energy convertor.
d Experiment with a thermal energy convertor.
✓**3256.3.2a** Convert mechanical energy to fluid energy with a pump and explain the process.
b Explain how a fan changes mechanical energy to fluid energy.
c Explain and demonstrate how an alternator converts mechanical energy to electrical energy.
d Investigate how a friction (inertia) welder changes mechanical energy to thermal energy.
e Identify workplace applications where technicians use and control mechanical energy convertors.

✓**3256.3.3a** Describe how a windmill converts fluid energy to mechanical energy.
b Explain how a turbine changes fluid energy to mechanical energy.
c Describe a process that converts fluid energy to electrical energy.
d Research and explain how an air conditioner uses fluids to remove thermal energy.
e Identify workplace applications where technicians use and control fluid energy convertors.

✓**3256.3.4a** Explain how an electric motor converts electrical energy to mechanical energy.
b Describe and investigate how a solenoid changes electrical energy to mechanical energy.
c Investigate how a high-resistance conducting wire converts electrical energy to thermal energy.
d Identify workplace applications where technicians use and control electrical energy convertors.

✓**3256.3.5a** Explain and demonstrate how a bimetallic strip changes thermal energy to mechanical energy.
b Convert thermal energy to fluid energy with a combustion engine and describe the process.
c Explain how a thermopile changes thermal energy to electrical energy.
d Identify workplace applications where technicians use and control thermal energy convertors.

✓**3256.3.6a** Determine the efficiency of a convertor that has mechanical input energy.
b Calculate the efficiency of a converter that has fluid input energy.
c Calculate the efficiency of a converter that has electrical input energy.
d Calculate the efficiency of a converter that has thermal input energy.

Standard 4 – Transducers

Conceptual Strand 4

Transducers sense the conditions of energy systems, helping monitor and maintain the safe operation of these systems.

Guiding Question 4

How is the safe operation of energy systems affected by transducers.

Course Level Expectations

CLE 3256.4.1 Define a transducer as a device that senses mechanical, fluid, electrical or thermal information.

CLE 3256.4.2 Describe the action of a transducer in general terms.

CLE 3256.4.3 Distinguish between an energy convertor and a transducer.

CLE 3256.4.4 Identify transducers that change mechanical signals into electrical signals and demonstrate the process.

CLE 3256.4.5 Identify transducers that change fluid signals into mechanical or electrical signals and investigate the process.

CLE 3256.4.6 Identify transducers that change electrical signals into mechanical or thermal information and investigate the process.

CLE 3256.4.7 Identify transducers that change thermal signals into mechanical, fluid, or electrical information and investigate the process.

Checks for Understanding (Formative/Summative Assessment)

✓**3256.4.1a** Explain what a mechanical transducer does.

b Explain what a fluid transducer does.

c Explain what an electrical transducer does.

d Explain what a thermal transducer does.

✓**3256.4.2a** Identify workplace applications where technicians use transducers.

✓**3256.4.3a** Solve problems that involve mechanical transducers.

b Solve problems that involve fluid transducers.

c Solve problems that involve electrical transducers.

d Solve problems that involve thermal transducers.

✓**3256.4.4a** Describe how a strain gage translates a mechanical input signal into an electrical output signal.

b Explain and demonstrate the piezoelectric effect.

c Explain how an accelerometer translates a mechanical input signal into an electrical output signal.

✓**3256.4.5a** Demonstrate how a bourdon gage changes a pressure input signal into a mechanical output signal.

b Compare pressure measurements made with a compound pressure gage to measurements made with a manometer.

c Investigate how a barometer changes a pressure input signal into a mechanical output signal.

d Describe how a flowmeter changes a fluid rate into an electrical signal.

e Explain how an anemometer changes a wind speed into an electrical signal.

✓**3256.4.6a** Describe how a moving coil transducer changes an electrical input into a mechanical output signal.

b Demonstrate how a meter reading depends on the interaction between a stationary magnetic field and the magnetic field created when current flows through the moving coil.

c Investigate why an ammeter has a low-resistance shunt connected in parallel with the transducer circuit and measure the resistance.

d Investigate why a voltmeter has a high-resistance resistor connected in series with the transducer circuit and measure the resistance.

e Calibrate the scale of a voltmeter.

f Describe how an electrostrictive transducer changes an electrical signal into a mechanical signal.

g Demonstrate what a photoconductive transducer does.
h Discuss the two types of transducers used in sonar systems.

✓**3256.4.7a** Demonstrate how a bimetallic strip changes a thermal input signal to a mechanical output signal.
b Describe how a thermograph changes a thermal input signal into recorded output information.
c Demonstrate how a thermocouple translates a thermal input signal to an electrical output signal.
d Explain how a thermistor changes a thermal input signal to an electrical output signal.

Standard 5 – Radiation

Conceptual Strand 5

Understanding electricity and magnetism is explained by the physics of electrons and magnets.

Guiding Question 5

How do the properties of electricity and magnetism relate to the physics of electrons and magnets?

Course Level Expectations

CLE 3256.5.1 Describe what is meant by electromagnetic radiation.
CLE 3256.5.2 Describe what is meant by nuclear radiation.
CLE 3256.5.3 Identify workplace applications where technicians measure or control radiation.

Checks for Understanding (Formative/Summative Assessment)

✓**3256.5.1a** Identify electromagnetic (EM) spectrum divisions, comparing their ranges of wavelength and frequency values.
b Identify four characteristics of EM radiation (wavelength, speed, frequency, and energy).
c Describe the speed of EM radiation in terms of wave frequency (f) and wavelength (λ).
d Investigate the characteristics of a photon, explaining how its energy depends on its wavelength or frequency.
e Solve problems for speed (v) and energy (E) of EM radiation by using the formulas: $v = \lambda t$; and $E=hf$, or $E=hc/\lambda$.
f Describe the wavelength limits, frequency limits and color content of the visible EM spectrum.

✓**3256.5.2a** Define nuclear decay.
b Identify three main components of nuclear radiation.
c Describe alpha particles, beta particles and gamma rays by giving their approximate mass and electrical charge and identify their symbols.

d Compare the relative hazards of alphas, betas and gammas by identifying materials that stop them.
e Define element, isotope, nuclide, atomic number, and mass number.
f Explain the meaning of symbols used to identify different nuclides.
g Differentiate between fission and fusion.
h Use Einstein's equation, $E = mc^2$, to change atomic mass to energy.
i Demonstrate how radiation energy follows the inverse square law.
j Detect nuclear radiation using appropriate instruments.

✓**3256.5.3a** Identify workplace applications where technicians measure and control EM radiation.
b Identify workplace applications where technicians work with nuclear radiation.
c Describe safety procedures that technicians must follow when working with nuclear radiation.

Standard 6 – Light and Optical Systems

Conceptual Strand 6

Understanding optics is accomplished by investigating the behavior and laws of light.

Guiding Question 6

How do the properties and behavior of light relate to the basic principles of optics?

Course Level Expectations

CLE 3256.6.1 Describe how light can be represented by light rays.
CLE 3256.6.2 Describe how light can be represented by waves.
CLE 3256.6.3 Identify the special characteristics of laser light.
CLE 3256.6.4 Identify several optical systems that process light.
CLE 3256.6.5 Identify workplace applications where technicians measure and control light.

Checks for Understanding (Formative/Summative Assessment)

✓**3256.6.1a** Explain and demonstrate the reflection of light.
b Use light ray diagrams in a drawing to show how light is reflected from plane (flat) mirrors.
c Use light ray diagrams in a drawing to show how light is reflected from spherical mirrors.
d Explain what is meant by the curvature and focal length of a mirror.
e Use light ray diagrams to show how light rays are reflected by a mirror.

f Discuss refraction of light and demonstrate the bending of the path of a light ray..
g Given a drawing of refracted light, calculate the index of refraction using Snell's law.
h Use light ray diagrams in a drawing to show how lenses bend and focus light.
i Determine the focal length of a lens.
j Use light ray diagrams to show how light is refracted through a lens.
k Distinguish between convex and concave lenses.
l Sketch examples of convex and concave lenses..
m Identify workplace applications where technicians use ray optics

✓**3256.6.2 a** Distinguish between constructive and destructive interference.
b Describe what is meant by interference fringes.

✓**3256.6.3 a** Explain what is meant by collimated light.
b Explain how light spreads as it travels.
c Identify the three main components of a laser and investigate their functions.
d Identify three main types of lasers.
e Investigate characteristics of laser light.
f Describe what is meant by coherent light.
g Calculate radiant power and power density.
h Explain how lasers can produce extremely high power densities on targets.

✓**3256.6.4 a** Explain diffraction.
b Use a light ray diagram to demonstrate how light diffracts.
c Explain diffraction grating.
d Investigate a grating spectrometer.
e Describe how the human eye forms an image of light.
f Investigate abnormalities (nearsightedness, farsightedness, astigmatism) and identify the appropriate corrective lenses.
g Describe how a camera forms an image on film.

✓**3256.6.5 a** Identify workplace applications where technicians use ray optics.
b Identify workplace applications where technicians use interference of light.
c Identify workplace applications where technicians use diffraction of light.
d Identify workplace applications where technicians use lasers.

Standard 7 – Time Constants

Conceptual Strand 7

Time constant describes how quickly nonlinear processes change.

Guiding Question 7

How would time constants be used describe nonlinear motion?

Course Level Expectations

CLE 3256.7.1 Distinguish between uniform change and nonuniform change..

CLE 3256.7.2 Identify systems where time constants are needed to describe system behaviour.

CLE 3256.7.3 Define three time constants (labeled $T_{1/2}$, T_{90} and τ).

CLE 3256.7.4 Identify workplace applications where technicians measure and control time constants.

Checks for Understanding (Formative/Summative Assessment)

✓**3256.7.1a** Draw a curve that shows a linear increase or decrease of a variable with time.

b Draw a curve that shows an exponential increase or decrease of a variable with time.

✓**3256.7.2** Explain why it is important to know the time constant of a thermocouple.

✓**3256.7.3a** Given the equation that describes how fast a vibration is slowing down (damped oscillation), identify the time constant and predict when the vibration is about 99% damped out.

b Given the equation that describes how fast a tank is emptied, identify the time constant and predict when the tank will be about 99% empty.

c Given the equation that describes the charging of a capacitor, identify the 1/e time constant and predict when the capacitor will be charged.

d Given the equation that describes the charging of a capacitor, identify the 1/e time constant and predict when the capacitor will be discharged.

e Draw a curve that represents the cooling rate of an isolated container of hot liquid located in a room at some cooler temperature (T).

✓**3256.7.4** Identify workplace applications in electrical and thermal systems where technicians measure or control time constants.